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Mr. Edmond J. Thomas
Chief, Office of Engineering and Technology
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

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AUG 17 2006

Federal Communications Commission
Office of the Secretary

Dear Mr. Thomas:

On March 17, 2005, staff members from the National Telecommunications and Information Administration (NTIA) Office of Spectrum Management (OSM) met with staff members from the Federal Communications Commission (Commission) International Bureau (IB). The purpose of the meeting was to discuss the Notice of Proposed Rulemaking (NPRM) to develop service rules for the Broadcasting-Satellite Service (BSS) in the 17.3-17.7 GHz (17 GHz) frequency range. Staff level discussions such as these before draft documents are brought into the Interdepartment Radio Advisory Committee can be very beneficial in facilitating the coordination of documents. I understand that our staffs had a productive exchange of information, and I commend the Commission staff for initiating the meeting. As a result of the meeting I would like to highlight several areas that NTIA believes should be addressed in the 17 GHz BSS NPRM.

Prior to the 1979 World Administrative Radio Conference (WARC-79), the 15.7-17.7 GHz band was allocated to the radiolocation service on a primary basis. At WARC-79, the band 17.3-17.8 GHz was reallocated to the fixed-satellite service (FSS) (Earth-to-space) limited to feeder links for the BSS, and the radiolocation service was downgraded to a secondary allocation in the 17.3-17.7 GHz band in all three International Telecommunication Union regions.[1] Subsequently, at WARC-92, the 17.3-17.8 GHz band segment was allocated to the BSS in Region 2 with an effective date of April 1, 2007. As you are aware, the U.S. government has a considerable investment in radiolocation operations in this frequency range. Therefore, we believe that a comprehensive discussion of the history of the frequency allocations is necessary. This discussion should include a description of the current and future radiolocation operations below 17.3 GHz. The enclosed document provides text that we request the Commission take into consideration in the development of the NPRM.

Investigations of several interference cases that have occurred between radar systems in the 2.7-3.7 GHz band and 4 GHz FSS earth stations have identified two interference-coupling mechanisms. These interference-coupling mechanisms, resulting from adjacent band operations of radars and FSS earth stations, include earth station receiver front-end overload from the radar signal into the wide front end of the earth station receiver, and interference from high-power pulsed unwanted emissions occurring in the FSS band. Given the high-power radar system

1. Nationally, footnote US 259 places on radiolocation stations an equivalent isotropically radiated power (EIRP) limit in order to protect fixed-satellite service geostationary operations.

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operations below 17.3 GHz, we believe that these same potential interference-coupling mechanisms will exist in the 17.3-17.7 GHz band and that they need to be addressed to avoid problems in the future. A solution that mitigates interference caused by earth station receiver front-end overload is installation of a filter on the front-end of the receiver. This filter must be installed ahead of the earth station receiver low noise amplifier; intermediate frequency filtering will not solve the problem. To address the front-end overload problem, we request that the NPRM include questions to make the BSS community aware of this potential problem.

Regarding high power pulsed unwanted emissions into the adjacent band, measurements performed by NTIA on a 4 GHz digital earth station receiver which employed error correction signal processing show that degradation of performance is directly related to the carrier-to-peak interference ratio (C/I).[2] The measurements also show that the potential interference impact is a function of the pulsed characteristics (pulse width, pulse repetition frequency, duty cycle) of the radar systems. However, these measurements are based on a 4 GHz earth station receiver. Therefore, we believe that it is necessary to include questions in the NPRM to determine the differences in signal processing between the 4 GHz and 17 GHz earth station receivers. Furthermore, to examine the potential impact of radar systems operating below 17.3 GHz on BSS earth station receivers, characteristics of the radar systems are necessary. The characteristics of the radar systems operating below 17.3 GHz to be used in assessing compatibility with 17.3 GHz BSS earth stations are provided in the enclosed document.

In a June 21, 2002 letter from NTIA to the Commission, we recommended that, given the long lead development and life cycle of radar and BSS systems, it would be beneficial for the radiolocation and BSS communities to exchange information to ensure compatibility.[3] These discussions should include the possibility of mitigation techniques that can be employed by both the radar systems and the BSS receivers. We recommend that the Commission in the NPRM encourage the BSS and the radar system operators to work together to ensure a common understanding of their respective system operations. We also recommend that questions be included in the NPRM to address possible interference mitigation techniques that can be employed and the ramifications of these techniques from the perspective of system performance and costs.

In previous letters from NTIA, we had informed the Commission that the Department of Defense anticipate(s) continued operation of radiolocation stations in the band 17.3-17.7 GHz even after the date of April 1, 2007 when the BSS is authorized to use the band in Region 2.[4] As

2. National Telecommunications and Information Administration, NTIA Report 02-393, *Measurements of Pulsed Co-Channel Interference in a 4 GHz Digital Earth Station Receiver* (May 2002).

3. Letter to Donald Abelson, Chief, International Bureau, Federal Communications Commission from Karl B. Nebbia, Deputy Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration (June 21, 2002).

4. Letter to Dale Hatfield, Chief, Office of Engineering and Technology, Federal Communications Commission from William T. Hatch, Interdepartment Radio Advisory Committee Chairman (October 29, 1998); Letter to Dale Hatfield, Chief, Office of Engineering and Technology, Federal Communications Commission William T. Hatch, Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration (March 29, 2000).

this possibility still exists, we also recommend that questions be included in the NPRM to address possible situations in which certain portions of the band 17.3-17.7 GHz would not be available for BSS in a limited number of geographic areas after April 1, 2007. We will work with the Commission to get this information into the public forum when available.

We again appreciate the staff-to-staff discussions initiated by the Commission on this topic. We recommend that the Commission take into consideration the issues raised in this letter. We believe that addressing potential compatibility problems early will help to ensure the long-term successful operation of the federal radar systems and BSS earth station receivers. If you have any questions about our comments, please feel free to contact me at 202-482-1850.

Sincerely,

Fredrick R. Wentland
Associate Administrator
Office of Spectrum Management

Enclosure

ENCLOSURE

HISTORY OF THE 17.3-17.7 GHz BAND

Prior to the 1979 World Administrative Radio Council (WARC-79) the entire band from 15.7-17.7 GHz was allocated to the radiolocation service on a primary basis. At WARC-79, the band 17.3-17.8 GHz was reallocated to the fixed-satellite service (FSS) (Earth-to-space) limited to feeder links for the broadcasting-satellite service (BSS), and the radiolocation service was downgraded to a secondary allocation in the 17.3-17.7 GHz band in all three International Telecommunication Union (ITU) Regions. Nationally, footnote US259 was established to place an equivalent isotropically radiated power (eirp) limit on radiolocation stations in order to protect these FSS geostationary operations.[1] Subsequently, at WARC-92, the band 17.3-17.8 GHz was allocated to the BSS in ITU Region 2 with an effective date of April 1, 2007.[2]

DIRECTV Enterprises, Inc. petitioned the Federal Communications Commission (Commission) to implement the BSS allocation prior to the effective date of April 1, 2007.[3] In a letter to the Commission, NTIA stated that they fully supported the position of the Department of Defense that the band 17.3-17.8 GHz cannot be used by the BSS prior to the effective date of April 1, 2007.[4] In the letter, NTIA further stated that the established international transition date must be maintained to protect the U.S. government's considerable investment in radiolocation operations in the band. Subsequently, the Commission reallocated the 17.3-17.7 GHz frequency segment to be designated for BSS downlink use effective April 1, 2007.[5] Additionally, in another letter to the Commission, NTIA cautioned that "not withstanding the allocation status of these

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1. *See* Footnote US259 – "Stations in the radiolocation service in the band 17.3-17.7 GHz, shall be restricted to operating powers of less than 51 dBW eirp after feeder link stations for the broadcasting-satellite service are authorized and brought into use."

2. *See* Radio Regulation 517 - In Region 2, the allocation to the broadcasting-satellite service in the band 17.3-17.8 GHz shall come into effect on 1 April 2007. After that date, use of the fixed-satellite (space-to-Earth) service in the band 17.7-17.8 GHz shall not claim protection from and shall not cause harmful interference to operating systems in the broadcasting-satellite service.

3. In the Matter of the Petition of DIRECTV Enterprises, Inc., To Amend Parts 2.25. and 100 of the FCC's Rules to Allocate Spectrum for the Fixed-Satellite Service and the Broadcast-Satellite Service, RM No. 9118 (June 5, 1997).

4. Letter to Regina Keeney, Chief, International Bureau, Federal Communications Commission, from Richard D. Parlow, Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration (December 30, 1997).

5. *In the Matter of Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Band for BSS Use*, Federal Communications Commission Report and Order, IB Docket No. 98-172 (Released June 22, 2000).

radiolocation stations with respect to the proposed BSS stations after April 1, 2007, these radiolocation stations may have to be accommodated."[6]

In 2002, NTIA sent a letter to the Commission highlighting the potential for adjacent band interference from radiolocation stations operating below 17.3 GHz, especially from aeronautical stations, to the BSS receiving earth stations in the band 17.3-17.8 GHz.[7] Because of the high power of the radars, interference may occur even though the radiolocation systems meet current regulations with respect to unwanted emissions. NTIA recommended that radiolocation and BSS communities begin discussions to ensure adjacent band compatibility. Subsequently, the Commission acknowledged NTIA concerns and agreed that discussions between the radiolocation and BSS communities at this early stage would be beneficial to ensuring adjacent band compatibility.[8]

The 15.7-17.3 GHz band is currently used by many different types of radar systems including land-based, transportable, shipboard, and airborne platforms. The functions performed by these radar systems include airborne and surface search, ground-mapping, terrain-following, maritime and target identification. Radar systems that might be developed in the future are likely to resemble the existing radars. Future radar systems are likely to have at least as much flexibility as current radars, including the capacity to operate differently in different azimuth and elevation sectors. It is reasonable to expect that some future designs may strive for a capability to operate in a wide band extending to the edge of the authorized allocation.

Future radar systems in this band are likely to have electronically-steerable antennas. However, current technology makes phase steering a practical and attractive alternative to frequency steering, and numerous radar systems developed in recent years for use in other bands have employed phase steering in both azimuth and elevation. Unlike frequency-steered radars, new phased-array radars can steer any fundamental frequency in the radar's operating band to any arbitrary azimuth and elevation within its angular coverage area. Among other advantages this would facilitate electromagnetic compatibility in many circumstances.

Some future radar systems are expected to have average-power capabilities at least as high as those of current systems. However, it is reasonable to expect that designers of future radars will strive to reduce wideband noise emissions below those of the existing radars that employ magnetrons or crossed-field amplifiers. Such noise

6. Letter to Dale M. Hatfield, Chief, Office of Engineering and Technology, Federal Communications Commission, from William T. Hatch, Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration, (March 29, 2000).

7. Letter to Donald Abelson, Chief, International Bureau, Federal Communications Commission, from Karl B. Nebbia, Deputy Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration (June 21, 2002).

8. Letter to Karl Nebbia, Deputy Associate Administrator, National Telecommunications and Information Administration, from Donald Abelson, Chief, International Bureau, Federal Communications Commission (July 15, 2002).

reduction is expected to be achieved by the use of solid-state transmitter/antenna systems. In that case, the transmitted pulses would be longer and the transmit duty cycles are substantially higher than those of earlier tube-type radar transmitters.

CHARACTERISTICS OF THE RADIOLOCATION SERVICE IN THE FREQUENCY RANGE 15.7-17.3 GHz

Summary

The following information on the radar systems operating in the 15.7-17.3 GHz frequency range is taken primarily from an ITU-R Draft New Recommendation (M Series) available on the ITU website to members.[9] It is provided to allow BSS service providers operating in the band 17.3–17.7 GHz to estimate the effects of emissions from adjacent band radar systems on their earth station receivers.

The technical characteristics of radar systems operating in the 15.7-17.3 GHz frequency range are determined by the mission of the system and vary widely. Procedures and methodologies to analyze compatibility between radar systems and systems in other services are contained in Recommendation ITU-R M.1461.

Technical characteristics

The 15.7-17.3 GHz frequency range is used by many different types of radar systems including land-based, transportable, shipboard and airborne platforms. Radiolocation functions performed in the band include airborne and surface search, ground-mapping, terrain-following, maritime and target-identification.

The major radar systems operating in this frequency range are primarily used for detection of airborne objects and ground mapping. They are required to measure target altitude, range, bearing used in generating terrain maps. Some of the airborne and ground targets are small and some are at ranges as great as 300 nautical miles (556 km), so these radar systems must have great sensitivity and must provide a high degree of suppression to all forms of clutter return, including that from sea, land and precipitation.

Largely because of these mission requirements, the radar systems using this frequency range tend to possess the following general characteristics:

- They tend to have high transmitter peak and average power.
- They typically use master-oscillator-power-amplifier transmitters rather than power oscillators. They are usually tuneable and some of them are frequency-agile. Some of them use linear-frequency modulation (chirp) or phase-coded intra-pulse modulation.
- Some of them have antenna mainbeams that are steerable in both azimuth and elevation using electronic beam steering.

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9. Document 8/BL/14-E, *Characteristics of and protection criteria for the radiolocation service in the frequency band 15.7-17.3 GHz* (February 22, 2005).

Table 1 shows systems that will likely impact the BSS earth station receivers, namely, the airborne ground-mapping radars. The lower power radars of "System 1" are included because of wider antenna beam widths (e.g., main beam and side lobe), which could increase the potential for interference. These systems currently tend to operate in the sub-band 16.2-17.3 GHz by provision of NTIA Manual Section 8.2.46,[10] but this could change at any time to also allow ground-based radars. The airborne radar systems tend to have antenna pointing capabilities such that mainbeam-to-mainbeam coupling can occur with BSS subscriber earth station antennas. The information provided in Table 1 should be sufficient for general calculation to assess the compatibility between these radars and BSS systems.

Table 1. Characteristics of Radar Systems Operating in the 16.2-17.3 GHz Frequency Range

Characteristics	System 1	System 2
Function	Search, track and ground-mapping radar (multi-function)	Search, track and ground-mapping radar (multi-function)
Platform type	Airborne, low power	Airborne, high power
Tuning range (GHz)	16.2-17.3	16.29-17.21
Modulation	Linear FM pulse	Linear and non-Linear FM pulse
Transmit peak power (W)	< 80	< 3260
Pulse width (↘s)	18.2; 49	120-443
Pulse rise/fall time (ns)	20	4
Pulse repetition rate (pps)	2041; 5495	900-1600
Duty Cycle	4-25%	< 50%
Output device	Travelling wave tube	Travelling wave tube
Antenna pattern type	Fan/pencil	Fan
Antenna type	Slotted waveguide	Phased array
Antenna polarization	Linear vertical	Linear vertical
Mainbeam Antenna gain (dBi)	25.6	38.0
Antenna elevation beamwidth (deg)	9.7	2.5
Antenna azimuthal beamwidth (deg)	6.2	2.2
Antenna horizontal scan rate	0-30 deg/s	0-5 deg/s

10. NTIA Manual Section 8.2.46 states that "Ground based and airborne radars ... shall have the capability to operate ... in the sub-bands 15.7 to 16.2 and 16.2 to 17.3 GHz, respectively."

Characteristics	System 1	System 2
Antenna horizontal scan type (continuous, random, sector, etc.)	±45 deg to ±135 deg (mechanical)	±30 deg (electronic, conical)
Antenna vertical scan rate	0-30 deg/s	0-5 deg/s
Antenna vertical scan type.[11]	−10 to −50 deg (mechanical)	0 to −90 deg (electronic, conical)
Antenna 1st side-lobe gain level	10 dBi @ 31 deg	18 dBi @ 1.7 deg
Antenna height	Aircraft altitude	Aircraft altitude
Chirp bandwidth (MHz)	< 640	< 1200
Transmitter RF emission bandwidth (MHz).[12] −3 dB −20 dB -40 dB -60 dB	 < 622 < 725 < 868 < 1040	 < 1200 < 1220 < 1300 < 1400

Radar Transmitters

The radars operating in the 15.7-17.3 GHz frequency range use a variety of modulations including unmodulated pulses, frequency-modulated (chirped) pulses and phase-coded pulses. Linear-beam and solid-state output devices are used in the final stages of the transmitters. The trend in new radar systems is toward linear-beam and solid-state output devices due to the requirements of Doppler signal processing. Also, the radars deploying solid-state output devices have lower transmitter peak output power and higher pulse duty cycles.

Typical transmitter RF emission (3 dB) bandwidths of radars operating in the band 15.7-17.3 GHz range from 60 kHz to 1200 MHz. Transmitter peak output powers range from 2 watts for solid-state transmitters to 20 kW for high-power radars using crossed-field devices (magnetrons) and linear-beam (traveling wave tube) devices.

Radar Antennas

A variety of different types of antennas are used on radars operating in the 15.7-17.3 GHz band. Many radars in this band operate in a variety of modes, including search, map and navigation (weather observation) modes. The antennas for such radars usually scan through 360➞ in the horizontal plane. Other radars in the band are more specialized and limit scanning to a fixed sector. The airborne ground mapping systems typically use

11. 0 degrees represents a horizontal orientation. Angles below horizontal are negative.

12. The radar center frequency is lowered if necessary to ensure that the -20 dB bandwidth is contained below 17.3 GHz. This may cause radar emissions to fall below 16.2 GHz, but they will still be within the allocated band.

synthetic aperture radar technology with fixed antenna pointing azimuth and declination angles with respect to aircraft velocity. Most radar systems operating in 15.7-17.3 GHz frequency range use mechanical scanning. However newer-generation radars use electronically scanned array antennas. Horizontal, vertical, and circular polarizations are used. Typical antenna heights for ground-based and ship-borne radars range from 8 m and 100 m above surface level, respectively. A nominal antenna height for airborne radar could be about 4500 m.

Considerations of Pulsed Interference

The effect of pulsed interference is more difficult to quantify than CW interference and is strongly dependent on receiver/processor design. The NTIA laboratory in Boulder, CO has conducted tests on a particular 4 GHz earth station receiver to determine susceptibility to co-channel pulsed interference. That report (NTIA Report 02-393) is available at (www.its.bldrdoc.gov/pub/pubs.php).[13] It showed that normal forward error correction processing built into the receiver was able to recover from low duty cycle pulsed interference even though (under certain combinations of small pulse widths and pulse repetition rates) the peak interference exceeded the desired signal by 60 dB or more. Interference was determined subjectively from a viewer's perspective in the form of noticeable tiling or freeze-frame effects. The applicability of that report for adjacent band pulsed interference is uncertain, and more work needs to be done studying the effects of adjacent band pulsed interference on digital receivers. Some adaptation will also be required since that report considered un-modulated pulses, whereas the radars of Table 1 are FM modulated. At any rate, a BSS receiver designer can greatly increase service robustness by considering implementing pulsed interference immunity techniques in their receiver designs. Various ITU resources may be helpful on this topic. For example, techniques for suppression of low-duty cycle pulsed interference are contained in Recommendation ITU-R M.1372.[14]

Possible Mitigation Techniques

There are various techniques that might be possible to implement in BSS receivers to mitigate against radiolocation interference, although they would have differing levels of practicality. For example, a relatively simple approach might be various techniques of antenna shielding to reduce sidelobes. A more sophisticated approach could allow such things as auxiliary side-lobe-blanking in receive antennas upon detection of interference. Frequency diversity might be another possibility for the lower BSS channels (adaptive selection of operating frequencies based on sensing of interference on one of two or more frequencies). There are many more ideas to consider, however, NTIA recommends that BSS systems employ at least the following two mitigation techniques:

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13. National Telecommunications and Information Administration, NTIA Report 02-393, *Measurements of Pulsed Co-Channel Interference in a 4-GHz Digital Earth Station Receiver* (May 2002).

14. The title of this recommendation is "Efficient use of the radio spectrum by radar stations in the radiodetermination service".

1. Employ adequate RF filtering to avoid front-end overload from adjacent band radar signals.
2. Based on a knowledge of radar characteristics, see what more can be done in the way of altering inter-leaving and/or other TVRO error correction techniques to improve survivable pulsed interference to carrier levels.

For both of these mitigation techniques it will be imperative for BSS and radiolocation communities to work together. Given the uncertainty of adjacent band radiolocation in terms of time, location, and modes of operation, of both current and especially future systems, the best protection against the effects of radiolocation is to implement these two concepts.